HIGH Tc METAL OXIDE SUPERCONDUCTOR CAVITIES

E. Minehara
Japan Atomic Energy Research Institute, Tokai Research Establishment,
Tokai, Naka, Ibaraki 319-11, Japan

ABSTRACT

Feasibility study for newly-developed metal oxide (Y-Ba-Cu-O, and La-Sr-Cu-O compounds) superconductor cavities was started to investigate their applicability on accelerating cavities at JAERI(Japan Atomic Energy Research Institute) in March 1987. A preliminary result of the study is reported on the fabrication method and the Tc measurement, RF and magnetic properties of the superconducting materials for this half year.

INTRODUCTION

In 1982, a feasibility study of the superconducting booster for the JAERI tandem accelerator was started at JAERI Tokai. These cavities for the booster were obtained by shaping bulk niobium sheet and niobium-copper explosive bonded sheet[1] and they gave excellent results[1]. However, at high accelerating fields, thermal breakdown induced either by electron loading or by enhanced heat dissipation due to surface defects has limited the performance of the Nb cavities because the available cooling capacity was very small on the surface.

Replacing bulky Nb with a higher Tc superconducting material should improve considerably the stability against breakdown because larger cooling capacity at higher temperature than 4.2K would provide a wide margin of the capacity. The required superconducting performance should then be provided by a so-called high Tc superconducting metal oxide material. In addition to the improved thermal stability, we maybe expect to build a cheaper superconducting accelerator without a very expensive liquid-He cryogenic system near future.

After the discovery and the confirmation of superconductivity with higher onset temperatures around 40 K and 95 K for La-Sr-Cu-O, and Y-Ba-Cu-O compound systems[2,3], respectively, a feasibility study in this direction was started at JAERI Tokai in March 1987. In the following section, a preliminary result of the study is reported on the fabrication method and the Tc measurement, magnetic and RF properties of the superconducting materials.

METAL OXIDE SUPERCONDUCTING MATERIALS

Figure 1 shows results of Tc and AC magnetic susceptability measurements for commercially-available Y-Ba-Cu-O compounds used in the present work. Two kinds of the Y-Ba-Cu-O compounds ,which were prepared from aqueous solution of Y-, Ba- and Cu-compounds, and from mixed powder of Y-, Ba- and Cu-oxides, were used to make the sintered discs and fine powdered materials.

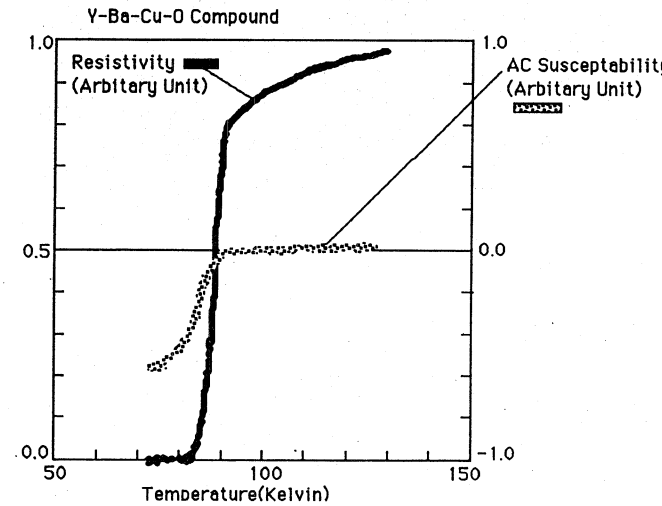

Fig.1 Tc and AC Magnetic Susceptability Measurements.

La-Sr-Cu-O compounds were prepared from mixed powder of La-, Sr- and Cu-oxides. Powdered materials of the La-Sr-Cu-O compounds were used to coat copper plates for checking the adherence and so on.

FABRICATION METHOD

Various metal oxide coating procedures, and machining of the metal oxide disc were considered to fabricate the cavities. These procedures are listed here, with, in brackets, the indication of the coating thickness tried at JAERI.

(a) Evaporation(0.01- several micrometers).
(b) DC-Arc Evaporation(0.01-1.0 micrometer).
(c) Magnetron Sputtering(0.01-a few micrometers).
(d) Ion Beam Sputtering(0.01- a few micrometers).
(e) Plasma-spray painting(10-500 micrometers).
(f) Brush-painting(1-100 micrometers).
(g) Machining of solid metal oxide discs.

Except for the machining, it has been experienced that annealing of the coated materials by using the listed procedures were mandatory to recover their higher Tc superconductivity. Although relatively low deposition temperature, and the high energy of the impinging atoms resulted in good adherence to the substrate in case of the sputtering procedures, very thin sputter-coated layer of the materials was found to be very fragile, and to be very easily-destroyed during the the annealing. Evaporation-coated layers were found to have the same difficulty with the sputtered. Therefore, the procedures from (a) to (d) have very serious difficulty in high temperature annealing.

The coated layer fabricated by inexpensive evaporation

and brush-painting procedures seemed to be too weak for manufacturing the cavities. Lack of the versatility in shaping complex structure of the cavities excludes the possibility to apply the procedure(g) with the fabrication for a large scale accelerator.

In order to fabricate 2.7GHz cavities, plasma-spray painting, brush painting and machining procedures have been used currently at JAERI.
Especially the plasma-spray painting procedure provided the very stable and strong adherence to the substrate, and good uniformity of the surface.

Y-Ba-Cu-O compounds have been used mainly to fabricate the cavities up to now. After the annealing of the coated tubes and cups, we have measured Tc of the coated materials on the tubes and cups to be around 90K by utilizing a He gas closed loop refrigerator and a superconductor test cryostat.

RF PROPERTIES

Measurements of the RF properties for the Y-Ba-Cu-O compound disc with cavity method at 3GHz, and with standing-wave method at 9GHz have been reported by people in Wuppertal[4], and by Tateno and Masaki in JAERI Tokai[5], respectively. Recently RF superconductivity in the Y-Ba-Cu-O compound disc was measured at 2.7GHz with the cavity method[6]. As illustrated in fig.2, the result shows that the Joule losses change markedly at the transition temperature around 87K and Q factor increases with decreasing temperature in the disc.

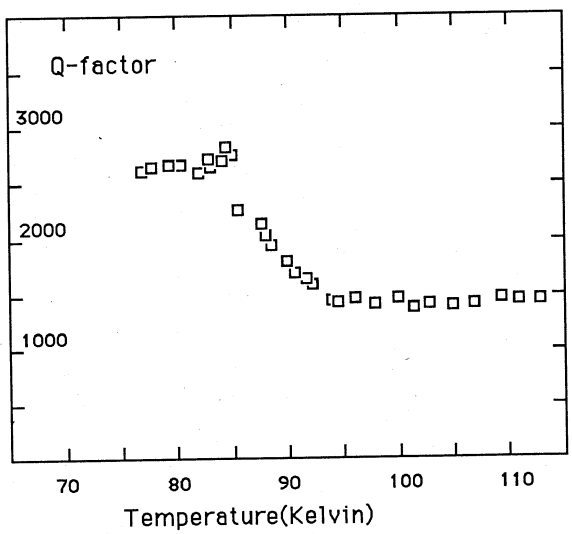

Fig.2 RF superconductivity of Y-Ba-Cu-O compound disc at 2.7GHz with cavity method.

REFERENCES

1) S.Takeuchi et al., Proc. 12th Linear Accelerator Meeting in Japan, Tokai(1987)p.36.
2) K.Kishio et al., Chem. Lett. 1987(1987)429.
3) M.K.Wu et al., Phys. Rev. Lett., 58(1987)908.
4) M.Hagen et al., to be published in the Journal of Magnetism and Magnetic Materials.
5) J.Tateno et al., to be published in the Japanese Journal of Applied Physics.
6) M.Ohkubo et al., Proc. 12th Linear Accelerator Meeting in Japan, Tokai (1987)p.42.